Survivable Space Tethers

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The two recent successful flights of the Small Expendable Deployer System (SEDS) have demonstrated the capability of tethers to deorbit payloads (SEDS–1) and to support scientific experiments in space (SEDS–2). This system was launched as a Delta secondary payload on an Air Force mission into a 350-kilometer, 35-degree inclination orbit. The 20-kilometer tether deployed a 35-kilogram instrumentated payload from the second stage downward into a stable, local, vertical orientation. This orbit afforded many stargazers a unique sight, as the tether was visible shortly after sunset or before sunrise as the Delta traveled overhead. Five days after the active portion of the mission was over, the tether was cut by a micrometeoroid or space debris, and the 7 kilometers of tether that remained attached to the Delta's second stage reentered approximately 60 days later. The severing emphasized the mission risk associated with flying tethers in space for long periods of time. Tethers can be built to survive a space environment according to work by R.L. Forward and R.P. Hoyt.[1] The Small Expendable Deployer System tethers are built with very large factors of safety, such as 80, so that they can survive hits by very small debris and micrometeoroids. As shown by Forward and Hoyt, a space tether can

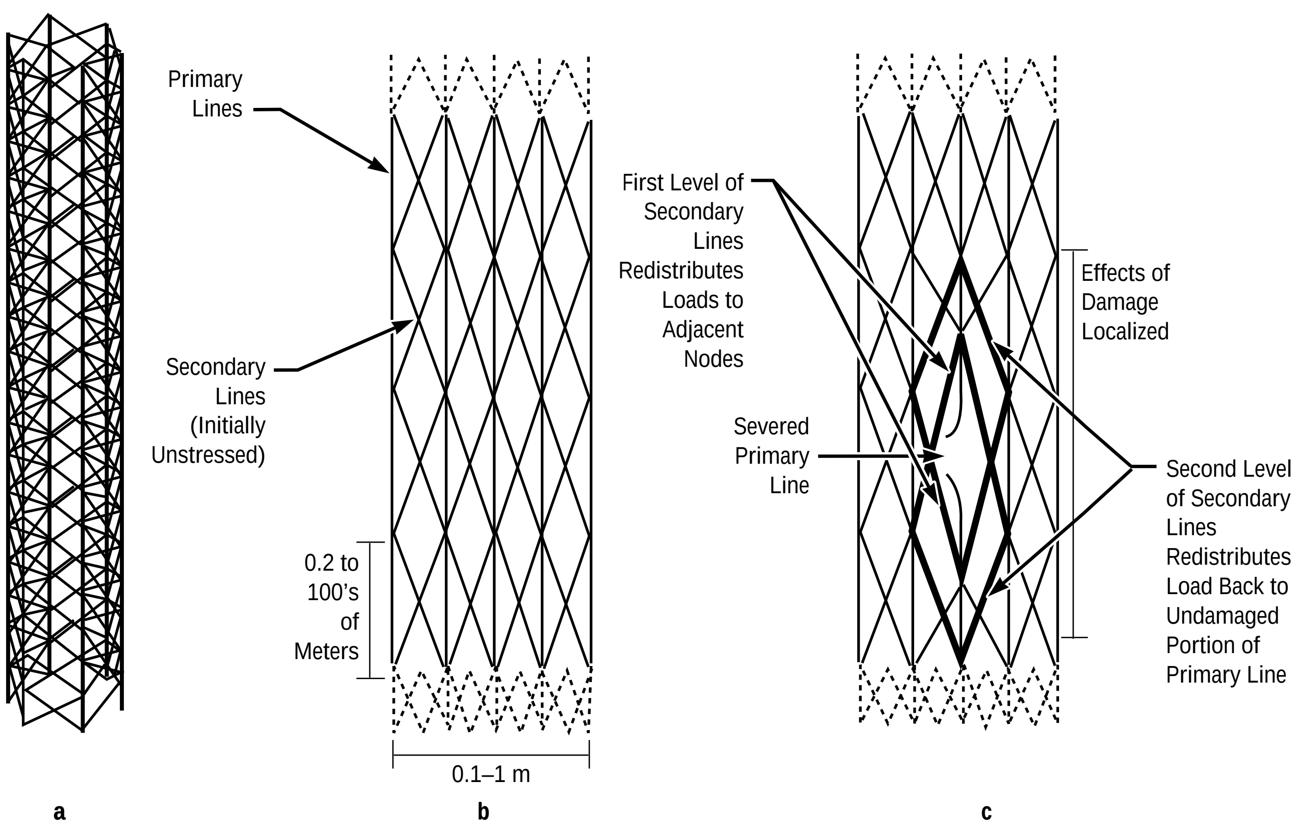

FIGURE 2.—(a) Section of Hoytether, (b) schematic of undisturbed Hoytether, (c) secondary lines redistributing load around a failed primary line without collapsing structure. Note that horizontal scale is expanded relative to vertical scale; in reality, the secondary lines are nearly parallel to the primary lines.

be built of many separated but interconnected strands in which the total cross section is relatively large. Named after its inventor, "Hoytether survivability" (fig. 2) is improved because it takes a larger particle to completely sever a tether built in this configuration.

For missions in which the tether safety factor can be relatively high, as in the first two Small Expendable Deployer System missions, micrometeoroid and debris survivability can be improved many orders of magnitude (fig. 3). The improved survivability can also be used as a justification for reducing the safety factor, thus lowering the weight of high-performance tether configurations.

[1]Forward, R.L. 1992. Fail-safe Multistrand Tether Structures for Space Propulsion. Twenty-Eighth Joint Propulsion Conference, Nashville, Tennessee. American Institute of Aeronautics and Astronautics, paper 92–3214.

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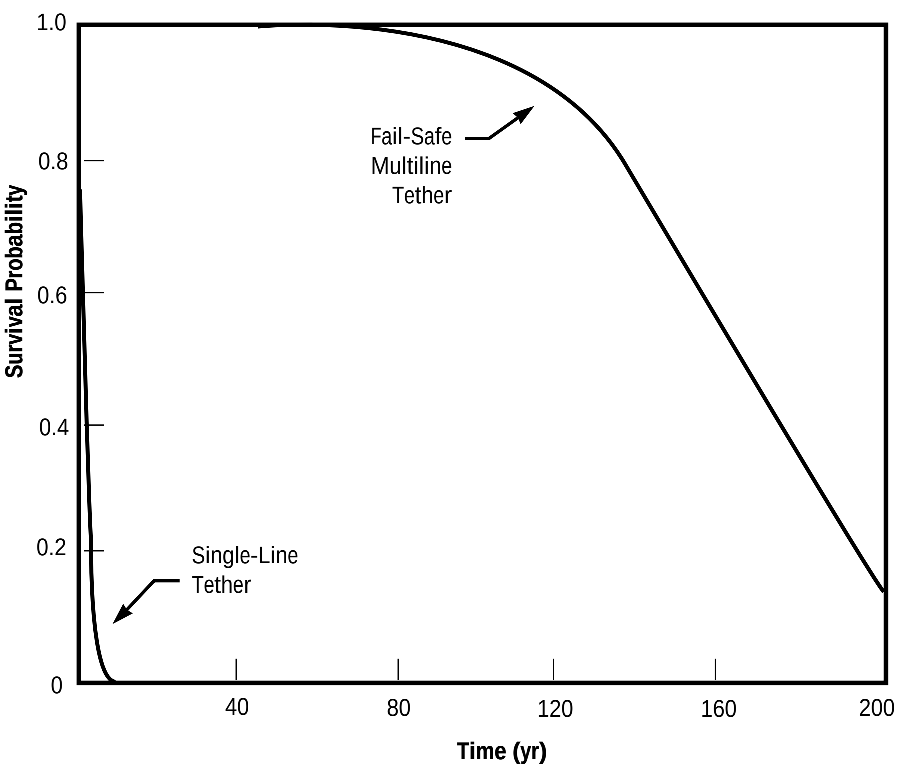

FIGURE 3.—Lifetime compensation of equal-weight, single-line and fail-safe, multiline tethers for a low-load mission.